BHARATHIDASAN UNIVERSITY

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Programme: M.Sc., Biomedical Science
(5 Year Integrated Program)

Course Title : Stem Cell Biology and Regenerative Medicine
Course Code : BM59C17

Unit-III
Tissue Engineering in Regenerative Therapies

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Introduction to Regenerative Medicine

Exploring the Future of Healing and Cellular Therapy

- **Definition**:
  - Regenerative medicine focuses on repairing, replacing, or regenerating damaged tissues and organs.
- **Applications**:
  - Organ regeneration
  - Treatment for chronic diseases
  - Addressing aging-related degeneration
- **Examples**:
  - 3D bioprinting for skin grafts
  - Gene therapy for inherited diseases

Introduction to Stem Cells

- **Definition**:
  - Stem cells are unspecialized cells capable of self-renewal and differentiation into various specialized cell types.
- **Types**:
  - Embryonic Stem Cells (ESCs)
  - Adult Stem Cells (ASCs)
  - Induced Pluripotent Stem Cells (iPSCs)
- **Unique Properties**:
  - Pluripotency: Ability to develop into any cell type (e.g., ESCs).
  - Multipotency: Limited differentiation potential (e.g., ASCs).

Role of Stem Cells in Regeneration

- **Mechanism**:
  - Replace damaged cells.
  - Stimulate resident cells to repair tissues.
  - Reduce inflammation through paracrine signaling
- **Examples**:
  - Hematopoietic stem cells (HSCs) in bone marrow transplantation for blood disorders.
  - Mesenchymal stem cells (MSCs) for cartilage repair in arthritis.

Stem Cell Lineage Tracing

- **Definition**:
  - A method to track the origin and differentiation pathway of stem cells.

- **Techniques**:
  - Genetic labeling (e.g., CRISPR-Cas9 systems).
  - Fluorescent markers (e.g., GFP-tagged cells).

- **Applications**:
  - Understanding tissue-specific stem cells in skin, liver, or intestine regeneration.
  - Unveiling the dynamics of cancer stem cells.

Early Development and Embryonic Stem Cells

- **Embryonic Stem Cells (ESCs)**:
  - Derived from the inner cell mass of the blastocyst.
  - Pluripotent in nature.

- **Role in Development**:
  - ESCs give rise to all three germ layers: ectoderm, mesoderm, endoderm.

- **Applications**:
  - Disease modeling (e.g., Parkinson’s disease).
  - Drug testing for toxicology.

Stem Cells in Neurodegenerative Diseases

- **Examples of Diseases**:
  - Alzheimer's, Parkinson's, Multiple Sclerosis.

- **Therapeutic Role**:
  - Replace lost or damaged neurons.
  - Promote axonal regrowth and remyelination.

- **Example**:

  Dopaminergic neuron differentiation from ESCs for Parkinson's disease treatment.

Stem Cells in Cardiovascular Diseases

- **Examples of Diseases**:
  - Myocardial infarction, heart failure.

- **Therapeutic Role**:
  - Regenerate damaged cardiac muscle cells (e.g., cardiomyocytes).
  - Improve angiogenesis to restore blood flow.

- **Example**:
  - MSCs injected into infarcted areas show improved heart function in clinical trials.

Challenges and Ethical Considerations

- **Challenges**:
  - Immune rejection of transplanted stem cells.
  - Risk of tumorigenesis due to uncontrolled growth.
- **Ethical Concerns**:
  - Embryonic stem cell research involves destruction of embryos.
  - Regulatory challenges in ensuring safe and equitable treatments.

Conclusion and Future Prospects

- **Conclusion**:
  - Stem cells hold immense potential for revolutionizing medicine.
  - Personalized therapies and regenerative approaches are the way forward.
- **Future Directions**:
  - Enhanced gene editing (e.g., CRISPR-Cas9).
  - Bioprinting whole organs using stem cells.